Corresponding author
Prof. Dr. H.V. Klapdor-Kleingrothaus
Max-Planck-Institut für Kernphysik
Saupfercheckweg 1
D-69117 HEIDELBERG
GERMANY
Phone Office: +49-(0)6221-516-262
Fax: +49-(0)6221-516-540
email: klapdor@gustav.mpi-hd.mpg.de

Data Acquisition and Analysis of the ^{76}Ge Double Beta Experiment in Gran Sasso 1990-2003

H.V. Klapdor-Kleingrothaus [1] A. Dietz, I.V. Krivosheina [2] and O. Chkvorets

Max-Planck-Institut für Kernphysik, PO 10 39 80, D-69029 Heidelberg, Germany

Abstract

Data acquisition in a long running underground experiment has its specific experimental challenges, concerning data acquisition, stability of the experiment and background reduction. These problems are addressed here for the HEIDELBERG-MOSCOW experiment, which collected data in the period August 1990 - May 2003. The measurement and the analysis of the data is presented. The duty cycle of the experiment was ∼80%, the collected statistics is 71.7 kg y. The background achieved in the energy region of the Q value for double beta decay is 0.11 events/ kg y keV. The two-neutrino accompanied half-life is determined on the basis of more than 100 000 events. The confidence level for the neutrinoless signal has been improved to a 4σ level.

[1] Spokesman of HEIDELBERG-MOSCOW (and GENIUS) Collaboration,
E-mail: klapdor@gustav.mpi-hd.mpg.de,
Home-page: *http://www.mpi-hd.mpg.de.non_acc/*
[2] On leave of the Radiophysical-Research Institute, Nishnii-Novgorod, Russia

Preprint submitted to Elsevier Science *19.11.2003*

1 Introduction

Since 40 years huge experimental efforts have gone into the investigation of nuclear double beta decay which probably is the most sensitive way to look for (total) lepton number violation and probably the only way to decide the Dirac or Majorana nature of the neutrino. It has further perspectives to probe also other types of beyond standard model physics. This thorny way has been documented recently in some detail [33,69].

The half-lives to explore lying, with the order of 10^{25} years, in a range on 'half way' to that of proton decay, the two main experimental problems were to achieve a sufficient amount of double beta emitter material (source strength) and to reduce the background in such experiment to an extremely low level. In both directions large progress has been made over the decades. While the first experiment using source as detector [59], had only grams of material to its disposal (10.6 g of CaF_2), in the last years up to more than 10 kg of enriched emitter material have been used. Simultaneously the background of the experiments has been reduced strongly over the last 40 years. E.g. compared to the first Germanium $\beta\beta$ experiment [81], working still with natural Germanium, containing the double beta emitter ^{76}Ge only with 7.8%, 40 years later the background in the HEIDELBERG-MOSCOW experiment is reduced by a factor of 10^4.

Nevertheless experiments have to run over years to collect sufficient statistics and this led to other experimental challenges: stable data acquisition and calibration over long time periods (more than a decade in the HEIDELBERG-MOSCOW experiment). The final dream behind all these efforts was less to see a standard-model allowed second-order effect of the weak interaction in the nucleus - the two-neutrino-accompanied decay mode - which has been observed meanwhile for about 10 nuclei - to observe neutrinoless double beta decay, and with this a first hint of beyond standard model physics, yielding at the same time a solution of the absolute scale of the neutrino mass spectrum.

In this paper we describe how these challenges have been mastered in the HEIDELBERG-MOSCOW experiment, which is running in the Gran Sasso Underground Laboratory since August 1990, and which is now, together with the R. Davis ^{37}Cl solar neutrino experiment [61], the Baksan Neutrino Scintillation telescope [62] which saw together with Kamiokande and IMB the first Supernovae neutrinos [63,64], Kamiokande and SuperKamiokande [65], Gallex (GNO) [66] and SAGE [66], and DAMA [104], one of the long-running underground experiments.

In our last publications [3,1,2] we presented an analysis of the data taken until May 2000. Since then we have taken three more years of data. In this paper

we report the result of the measurements over the full period August 1990 until May 2003. The better quality of the new data and of the present analysis, which has been improved in various respects, allowed us to significantly improve the investigation of the neutrinoless double beta decay process, and to deduce more stringent values of its parameters.

2 Performance of the Experiment and Data Taking

Comment:

full version
(50 pages, 36 figures, 9 tables),
zipped ps file (size $\sim$ 21 MB)
or pdf format (size $\sim$ 26 MB),
can be found in
http://www.mpi-hd.mpg.de/
non_acc/super.html

In press in NIM A, 2004.